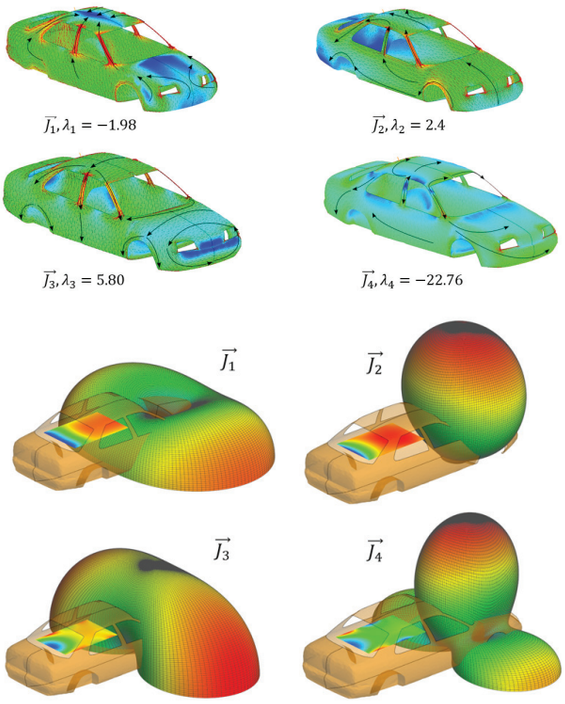
FEKO
Comprehensive Electromagnetic Solutions

Intelligent Design with Characteristic Mode Analysis

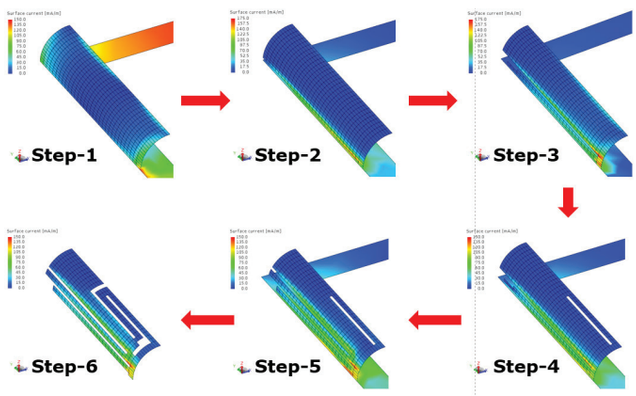
INTRODUCTION

The theory of Characteristic Mode Analysis (CMA) [1, 2] is a well-known method that allows for the analysis of arbitrary structures by solving a generalised eigenvalue equation derived from the Method of Moments (MoM) impedance matrix. After running a CMA simulation the eigenvalues (EV), modal significance (MS) and characteristic angle (CA) are available for the modes that were calculated. A mode can be considered resonant when EV=0, MS=1 or CA=180. Modal currents, near or far fields are also useful to visualise and interpret modal behavior, and can be applied either to enhance or suppress certain modes depending on the requirements [3]. If an excitation is present the modal excitation and modal weighting coefficients are calculated, giving an indication of how well the excitation will excite each mode.

The abovementioned parameters are what make CMA such an novel alternative for design optimisation: the fundamental insight that is provided in terms of the resonant performance of the structure leads to a systematic and intelligent approach, which in turn may lead to significantly less iterations to achieve an optimised performance.



Modal currents on a car chassis (top) and corresponding modal near field and far field patterns (bottom)

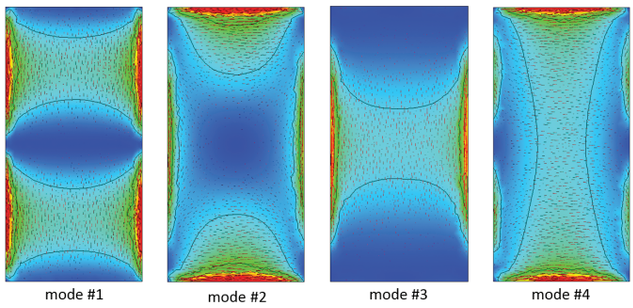


The antenna is designed by modifying the metal sheet systematically based on the modal current distribution

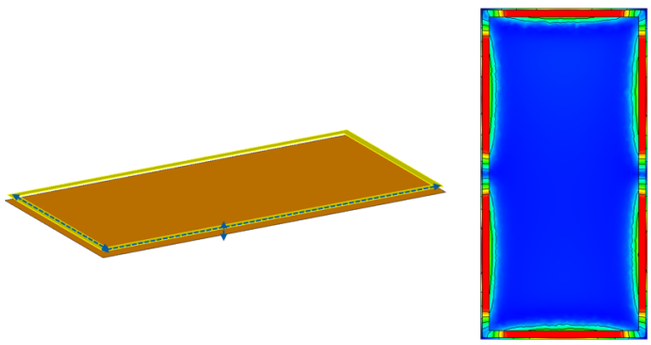
CMA FOR ANTENNA DESIGN

CMA is widely applicable to antenna design, placement and integration. One example is illustrated in [4] where a mobile antenna is designed that operates in the LTE 1.8 GHz band. CMA was used to calculate the modal currents on a surface defined for the antenna, a resonant path was created by etching slots into the sheet where the amplitude of the modal current is low, leaving metal strips where the modal currents are high. After each modification the modal significance is re-analysed to ensure that the resonance is still at 1.8 GHz (MS=1).

While [4] concentrated on antenna design aspects, in [5] CMA was used to facilitate the integration of a dual channel MIMO antenna into a mobile device. The PCB modal current distribution at resonance can be useful for various aspects during the integration process, including optimum placement of the antenna on the PCB, passive test cable routing, modification of PCB geometry and design of passive resonators. The display frame geometry and battery position were optimised with CMA to improve the overall MIMO performance. Following this approach an improvement of 5% in radiation efficiency, 5 dB reduction in coupling between elements and up to 1 dB in mean effective gain were achieved while the envelope correlation coefficient was acceptably low. The advantages that CMA offered in this study were fast simulations (in the order of a few minutes) that brought valuable insight and ultimately led to an improved design during the integration process.



Instantaneous modal currents on the PCB, 2.6 GHz



The display frame geometry is tweaked using CMA to design a passive resonator

CONCLUSIONS

CMA provides a novel approach to a broad range of problems, ranging from antenna design and placement, to EMC and coupling. This stems from the parameters that CMA calculates, which describe the fundamental resonant behaviour of the structure. When applied with the correct interpretation, the possibilities for intelligent design are endless.

REFERENCES

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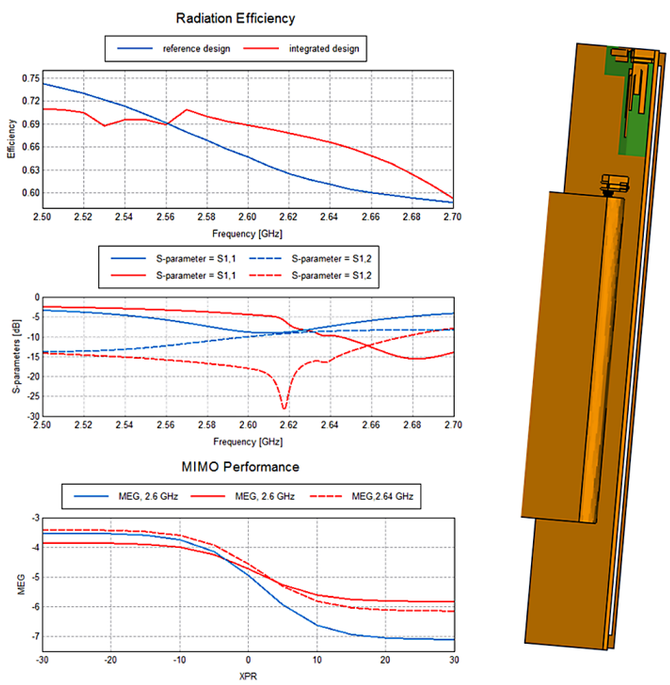
[3] M. Cabedo-Fabrés, E. Antonio-Daviu, A. Valero-Nogueira and M. F. Bataller, "The Theory of Characteristic Modes Revisited: A Contribution to the Design of Antennas for Modern Applications," IEEE Trans. Ant. and Propagat. Magazine, vol. 49, no. 5, pp. 52-68, October 2007.

[4] G. Gampala, C. J. Reddy, "Compact LTE Antenna Design Using the Theory of Characteristic Modes for Smart Phone Applications," IEEE Ant. and Propagat. Symposium, July 2013.

[5] P. Futter, G. Gampala, C.J. Reddy, "MIMO Antenna Integration for LTE," PIERS, August 2013



CMA optimised performance of the antenna, display frame and battery compared to the reference design